**Process Control System (Abstract)**

Technological advancements in process monitoring, control and industrial automation over the past decades have contributed greatly to improve the productivity of virtually all manufacturing industries throughout the world.

While 90% of global production is still controlled by analog instrumentation, almost all the controls installed as a part of a new plant or plant expansion are Digital Control Systems DCS connected by digital networks.

Nowadays, in this era of digital buses, one can plug in a laptop or use a wireless hand tool to instantly establish access to all the data, displays and intelligence that resides anywhere on the DCS network. This capability, in combination with the self-tuning, self-diagnosing and optimizing features of modern process control, makes both startup activity and operational routines much easier and more efficient.

This thesis will look at implementing a computer based process control system for raw mill on an oil plant. This will be achieved with VB.net, SQL server as the back end, Measurement Computing USB Card and Instacal for acquiring data from sensors.
Chapter One

Introduction

In former times, oil extraction was done exclusively with presses. In most oil mills, oil extraction is done with expellers as pre extraction before solvent extraction or as direct press extraction. Oil Mills are used for high oil content seeds like sunflower, rapeseed, castor, soyabean, sheanut, copra, mango kernels etc. In smaller capacity plants, it is mostly used as direct extraction but as the capacity increases, oil mills are used for pre extraction.

Palm Oil Milling Process

Palm oil is extracted from fresh fruit bunches (FFB) by mechanical process, where a mill commonly handles 60 to 100mt per hour of FFB. The modern palm oil mill of today is based predominantly on concepts developed in the early 50s (Mongana Report). An average size FFB weighs about 20-30kg and contains 1500-2000 fruits. The FFBs are harvested according to harvesting cycles, and delivered to the mills on the same day. The quality of crude palm oil is dependent on the care taken after harvesting, particularly on the handling of the FFBs.

A palm oil mill produces crude palm oil and kernels, as primary products and biomass as secondary product. The capacity of mills varies between 60- 100 tons FFB/h. A typical mill has many operation units as shown in Figure 2. This comprises of sterilization, stripping, digestion and pressing, clarification, purification, drying and storage. For the kernel line, there are steps such as nut/fibre separation, nut conditioning and cracking, cracked mixture separation, and kernel drying, storage. The dried kernels are often sold to palm kernel crushers for extraction of crude palm kernel oil. In some integrated plants, kernel crushing facilities exist side by side at the same complex.
**Figure 2.** Flow chart for the palm oil milling process

**Steps Undertaken During Oil Milling**

- Sterilisation
- Stripping
- Digestion and Pressing
- Clarification
- Decanters

In the next chapter, I will be explaining in details the above steps
Introduction to Process Control

Control in process industries refers to the regulation of all aspects of the process. Precise control of level, temperature, pressure and flow is important in many process applications. This thesis introduces you to control in process industries, explains why control is important, and identifies different ways in which precise control is ensured.

The Importance of Process Control

Refining, combining, handling, and otherwise manipulating fluids to profitably produce end products can be a precise, demanding, and potentially hazardous process. Small changes in a process can have a large impact on the end result. Variations in proportions, temperature, flow, turbulence, and many other factors must be carefully and consistently controlled to produce the desired end product with a minimum of raw materials and energy. Process control technology is the tool that enables manufacturers to keep their operations running within specified limits and to set more precise limits to maximize profitability, ensure quality and safety.

Process control refers to the methods that are used to control process variables when manufacturing a product. For example, factors such as the proportion of one ingredient to another, the temperature of the materials, how well the ingredients are mixed, and the pressure under which the materials are held can significantly impact the quality of an end product. Manufacturers control the production process for three reasons:

- Reduce variability
- Increase efficiency
- Ensure safety

Reduce Variability

Process control can reduce variability in the end product, which ensures a consistently high-quality product. Manufacturers can also save money by reducing variability. For example, in a gasoline blending process, as many as 12 or more different components may be blended to make a specific grade of gasoline. If the refinery does not have precise control over the flow of the separate components, the gasoline may get too much of the high-octane components. As a result, customers would receive a higher grade and more expensive gasoline than they paid for, and the refinery would lose money. The opposite situation would be customers receiving a lower grade at a higher price.
**Increase Efficiency**

Some processes need to be maintained at a specific point to maximize efficiency. For example, a control point might be the temperature at which a chemical reaction takes place. Accurate control of temperature ensures process efficiency. Manufacturers save money by minimizing the resources required to produce the end product.

**Ensure Safety**

A run-away process, such as an out-of-control nuclear or chemical reaction, may result if manufacturers do not maintain precise control of all of the processing variables. The consequences of a run-away process can be catastrophic. Precise process control may also be required to ensure safety. For example, maintaining proper boiler pressure by controlling the inflow of air used in combustion and the outflow of exhaust gases is crucial in preventing boiler implosions that can clearly threaten the safety of workers.

**Problem Statement**

90% of Oil milling industries currently uses microcontroller based systems which has limitations. Some of the limitations are listed below;

- Absence of real-time chart recorders to view trends of events during milling
- Absence of data storage facilities. As a result of this, you cannot play back historical data
- Poor Visualization. No proper interface for monitoring milling processes

**Objective of the Study**

The objective of this thesis is to design a computer based process control system to replace the existing microprocessor based system. This is to be actualized with data acquisition technology

**Scope of Study**

The scope of this thesis is to monitor and control the different sensors positioned at strategic places e.g. sensors positioned at the sterilization points etc. Below is a list of possible sensors that the system will be able to monitor and control;
1. Monitoring of Sensors
   - Pressure sensing diaphragms, strain gauges, capacitance cells
   - Resistance temperature detectors (RTDs)
   - Thermocouples
   - Orifice plates
   - Pitot tubes
   - Venturi tubes
   - Magnetic flow tubes
   - Coriolis flow tubes
   - Radar emitters and receivers
   - Ultrasonic emitters and receivers
   - Annubar flow elements
   - Vortex shedder
2. Data Storage and playback
3. Visualization of Process Control Parameters (Improved Interface)

**Definition of Terms**

As in any field, process control has its own set of common terms that you should be familiar with and that you will use when talking about control technology.

**Process Variable**

A *process variable* is a condition of the process fluid (a liquid or gas) that can change the manufacturing process in some way.

**Setpoint**

The *setpoint* is a value for a process variable that is desired to be maintained. For example, if a process temperature needs to be kept within 5 °C of 100 °C, then the setpoint is 100 °C.

**Error**

*Error* is the difference between the measured variable and the set point and can be either positive or negative.

**Offset**
Offset is a sustained deviation of the process variable from the set point.

**Load Disturbance**

A load disturbance is an undesired change in one of the factors that can affect the process variable.

**Control Algorithm**

A control algorithm is a mathematical expression of a control function.

**Manual And Automatic Control**

Before process automation, people, rather than machines, performed many of the process control tasks. For example, a human operator might have watched a level gauge and closed a valve when the level reached the set point. Control operations that involve human action to make an adjustment are called manual control systems.

Conversely, control operations in which no human intervention is required, such as an automatic valve actuator that responds to a level controller, are called automatic control systems.

**Closed Control Loops**

A closed control loop exists where a process variable is measured, compared to a set point, and action is taken to correct any deviation from setpoint. An open control loop exists where the process variable is not compared, and action is taken not in response to feedback on the condition of the process variable, but is instead taken without regard to process variable conditions. For example, a water valve may be opened to add cooling water to a process to prevent the process fluid from getting too hot, based on a pre-set time interval, regardless of the actual temperature of the process fluid.

**Chapter Two**
Literature Review

The purpose of this chapter is to expantiate the different stages involved in oil milling and also give a detailed description of what process control system is as related to oil milling.

Analysis of the Existing System

Sterilization

This first step in the process is crucial to the final oil quality as well as the strippability of fruits. Sterilization inactivates the lipases in the fruits, and prevents build-up of free fatty acids (FFA). In addition, steam sterilization of the FFBs facilitates fruits being stripped from the bunches. It also softens the fruit mesocarp for digestion and release of oil, and conditioning of nuts to minimize kernel breakage. Air is removed from the sterilizer by sweeping in steam in single-peak, double-peak or triple-peak cycles. In general, bunches are cooked using steam at 40psig. in horizontal cylindrical autoclaves for 60-90 minutes. The length of the sterilizer is dependent on the number of cages required for operation of the mill. Each cage can hold 2.5 to 10tons of FFB. Steam consumption varies from 140 kg/ton FFB for a single-peak cycle to 224 kg/ton FFB for a triple – peak cycle (Sivasothy et al.1986). Inadequate sterilization affects the subsequent milling processing stages adversely.

In recent years, new technology on sterilization saw the introduction of continuous sterilizers. Sivasothy’s (2006) continuous sterilizer showed improved fruit strippability, even with usage of low pressure steam or atmospheric steam. The new system consists of conveyor belt taking crushed FFBs into the continuous sterilizer, where the fruits are sterilized and subsequently discharged. This reduces much of the machinery associated with conventional sterilizers. In addition, there are cost savings in terms of manpower requirements, and maintenance.

Vertical sterilizers are also available, which are much cleaner and easier to operate than conventional sterilizers.

Another type of sterilizer technology, the Tilting sterilizer (Loh, 2010) also eliminates much of the machinery associated with conventional sterilizers. The technology is the latest design that offers improved milling efficiency, and reduced labour and maintenance cost.
Stripping

Stripping or threshing involves separating the sterilized fruits from the bunch stalks. Sterilized FFBs are fed into a drum stripper and the drum is rotated, causing the fruits to be detached from the bunch. The bunch stalks are removed as they do not contain any oil. It is important to ensure that oil loss in the bunch stalk is kept to a minimum. The stalks are often disposed by incineration, giving ash as potash fertilizer, and fuel for boilers. Others are transported to the plantations for use as fertilisers in mulching near the palms. The total oil loss absorbed on the stalks depends on the sterilizing conditions and partly on the way the stripper is operated. Prolonged sterilization will increase oil loss in stalks. Irregular feeding of the stripper may also result in increase of oil loss in stalks. Stalks which have fruits still attached on them are called hard bunches, and have to be recycled back to sterilizers for further cooking. Hard bunches are detected by visible inspection.

Digestion and Pressing
After stripping, the fruits are moved into a digester where, the fruits are reheated to loosen the pericarp. The steam heated vessels have rotating shafts to which are attached stirring arms. The fruits are rotated about, causing the loosening of the pericarps from the nuts. The digester is kept full and as the digested fruit is drawn out, freshly stripped fruits are brought in. The fruits are passed into a screw press, where the mixture of oil, water, press cake or fibre and nuts are discharged. Improvements in press designs have allowed fruits to undergo single or multiple pressing. Second stage pressing on the press cake fibres enables more oil to be extracted.

**Clarification**

A mixture of oil, water, solids from the bunch fibres is delivered from the press to a clarification tank. In the conventional process, separation of the oil from the rest of the liquor is achieved by setting tanks based on gravity. The mixture containing the crude oil is diluted with hot water to reduce its viscosity. A vibrating screen helps remove some of the solids. The oil mixture is heated to 85-90°C and allowed to separate in the clarification tank. A settling time of 1-3 h. is acceptable. Oil from the top is skimmed off and purified in the centrifuge prior to drying in vacuum dryer. The final crude palm oil is then cooled and stored. The lower layer from the clarification tank is sent to the centrifugal separator where the remaining oil is recovered. The oil is dried in vacuum dryers, cooled and sent to storage tanks.

**Decanters**

Decanters are also used in some mills as an alternative to separating the suspended solids from crude palm oil in a clarification tank. Various design of decanters are available. Their usage is however, hampered by higher maintenance costs from the wear and tear. An advantage to the use is the reduction in palm oil mill effluent. Sulong and Tan (1996) had proposed a membrane filter press for oil and solids recovery. The cake is discharged as solid waste for fertilizer production or animal feed, while the oil is recovered.

**Oil Losses during Processing**

Oil losses in mills vary from mill to mill, and much attention is given to the control of oil loss. The main oil loss are from sterilizer condensate, empty bunches, fruit loss in unstrapped bunches, press cake fibre, nuts and sludge. Over-ripe bunches will lose more oil during sterilization. To minimize this, shorter sterilizer cycles
are used, or better control of bunch ripeness and quality will help ensure less wastage. A typical oil loss in sterilizer is estimated to be 0.1% to FFB. Oils recovered from sterilizer condensate should be used as technical oils, as they often contain higher iron content and would reduce oil stability if mixed with the crude production oil.

**Kernel Production**

The press cake from the digester is fed to a vertical column (depericarper) where air is channeled to lift the fibre, thus separating the fibre from the nuts. The nuts are passed to a polishing drum at the bottom of the depericarper, where pieces of stalks are removed. A nutcracker cracks the nuts after the conditioning and drying process. A ripple mill is also used instead of nut cracker. The mixture of cracked nuts and shells are separated via a winnowing system, followed by a hydrocyclone or a clay bath. A hydrocyclone uses centrifugal force to separate the kernel from the shell using water. The clay bath principle works on the specific gravity of kernel of 1.07 and the shell of 1.17. The kernels will float while the shells sink in a clay bath mixture of SG 1.12. The kernels are then dried in hot air silos to moisture content of less than 7%. About 0.4mt of kernels are produced with every mt of CPO.

**Biomass**

The amount of solid palm oil waste available from a mill can be substantial. This consists of empty fruit bunches (EFB), palm kernel shell, mesocarp fibres, and possibly solids from decanters. In most cases, this biomass especially, the EFB, palm kernel shell and mesocarp fibres are used as fuel in the mill, generating enough electricity for running the mill. Besides usage as fuel, the biomass together with fronds and trunks can be left in the fields as fertilizers. EFBs can also be combined with polyurethane ester (PU) to prepare medium density fibreboard, giving higher impact strength and better water resistance (Khairiah, 2006).

**The Automated Process**

**Process Control System**

A process-control system monitors a manufacturing environment and electronically controls the process or manufacturing flow based on limits set by the user. In a representative process-control system, a measuring device (laser diode) is used to detect gas or liquid present in an industrial environment. The frequency signature of the specific gas or liquid is sent to the receiver where it is converted to
a digital signal and then identified by the processor. This identification is used by the host controller and automation system for system tasks.

**Types of control systems**

In practice, process control systems can be characterized as one or more of the following forms:

- **Discrete** – Found in many manufacturing, motion and packaging applications. Robotic assembly, such as that found in automotive production, can be characterized as discrete process control. Most discrete manufacturing involves the production of discrete pieces of product, such as metal stamping.

- **Batch** – Some applications require that specific quantities of raw materials be combined in specific ways for particular durations to produce an intermediate or end result. One example is the production of adhesives and glues, which normally require the mixing of raw materials in a heated vessel for a period of time to form a quantity of end product. Other important examples are the production of food, beverages and medicine. Batch processes are generally used to produce a relatively low to intermediate quantity of product per year (a few pounds to millions of pounds).

- **Continuous** – Often, a physical system is represented through variables that are smooth and uninterrupted in time. The control of the water temperature in a heating jacket, for example, is an example of continuous process control. Some important continuous processes are the production of fuels, chemicals and plastics. Continuous processes in manufacturing are used to produce very large quantities of product per year (millions to billions of pounds).

Applications having elements of discrete, batch and continuous process control are often called hybrid applications.

In the new process, the closed-knit arrangement of the spikelet in bunches is first disrupted using a double-roll crusher. The bunches are then heated using live steam at low pressure to facilitate continuous processing.

The continuous sterilization process provides the impetus for new paradigms in the design and operation of palm oil mills. The use of technology that is simple and uncomplicated ensures that the system is competitively priced. It eliminates the use of sterilizer cages, rail tracks, overhead cranes, tippers, transfer carriages and tractors and thereby facilitates the design and construction of mills having
significantly smaller footprints than conventional mills.

A NEW PARADIGM FOR AUTOMATION OF MILLS

A significant advantage of continuous sterilization over batch sterilization is that it renders the palm oil milling process a continuous operation from start to finish, making it cost-effective to automate the bunch handling operations. A plant-wide control system can now be used to facilitate overall monitoring and control of the mill from a control room. The four most important functions of this control system are described in the next section.

- **Real-time process monitoring**

  All the important information pertaining to the status of equipment and processes can be monitored by the control system using animated process graphic and text displays. Real-time monitoring permits much more comprehensive and in-depth assessment of equipment and process performance and process dynamics than is possible manually.

- **Automatic Control**

  Control loops can be used for all the critical process variables. Although control loops can be used to ensure that process parameters such as temperature and level are maintained at desired values, the added complexity and the cost of implementing such control loops can only be justified if there are benefits. Until process analysis studies are able to confirm the benefits of automatic control, remote monitoring from the control room and periodic adjustments by field operators will be considered sufficient.

- **Centralized Motor Control**

  To promote greater automation and to facilitate monitoring and control of the mill from a control room, the plant-wide control system can be used to monitor the on/off/trip status of all motors. The system can also monitor the load on all equipment in the mill and provide alarms when the load is abnormally high.

  The system can be used to start-up and shutdown sections of the mill and to perform emergency shutdown if there is an abnormal condition.

  Inverters can be used for the more critical motors to facilitate changing the retention time and/or throughput from the control room.

- **Visual Surveillance**

  A CCTV system can be used to monitor operations that need to be closely monitored but cannot yet be completely automated and to beef up security surveillance in the palm oil mill.

**Computer Based Process Control System**

By using a supervisory control and data acquisition (SCADA) system consisting
of a network of personal computers (PCs), the new plant-wide control system provides a cost-effective and comprehensive solution to the automation requirements of palm oil mills. The system enables you to manage the process as a complete system, with control over the inter-relationships of various sub-systems to improve the overall performance.

The system comprises of Data Acquisition Cards, Personal Computers as sub-systems to enable the field operators to execute some of the monitoring and control functions without having to communicate with the control room operators.

The (human-machine interface / supervisory control and data acquisition) software supports communication with all the popular types of PLCs and Sensors available in the market. The software also includes features that facilitate process graphic displays, historical data analysis, statistical process control and formatting of printed reports.

**Centralized Motor Control**

Monitoring of the motor load and the running hours of the equipment is useful for trouble-shooting purposes and for scheduling the maintenance of the machinery to minimize the mill downtime. The alarm provided by the system when the load exceeds some preset value permits maintenance personnel to anticipate problems and take corrective action to improve operational efficiency and avert costly disruptions and incidents.

In the case of the continuous sterilization plant, the control system is also able to automatically shut down the plant if the load is abnormally high. The system has also been successfully applied for automatic start-up and shutdown of the plant. Such control capabilities are greatly appreciated by the users and can be easily extended to the rest of the mill.

**WHY MILLS SHOULD AUTOMATE**

- Compelling issues such as labor shortages, more stringent regulations, increasing environmental concerns and escalating production costs.
- Significant advances in automation technology in recent years, spurred on by hardware and software developments in information and communication technology (ICT).
- Continuous sterilization makes palm oil mill automation cost-effective.

**BENEFITS**

- Increase in operator productivity leading to reduction in the number of operators.
- Improved monitoring of milling processes and equipment by operators.
- Reduction in mill downtime and improvements in mill utilization.
- Improvements in steam management and reduction in black smoke emission from boiler stacks.
- Improvements in programming the scheduled maintenance of equipment due to real-time tracking of performance.
- More consistent process performance (reduced variability).
- Reduction in the losses of oil and kernel from milling processes.
- Improvements in the quality of the finished products.
- Provision of a more conducive work environment for operators.

**PRACTICAL DISCRPTION OF THE AUTOMATED PROCESS CONTROL**

**Control Loop in Process Control**

Imagine you are sitting in a cabin in front of a small fire on a cold winter evening. You feel uncomfortably cold, so you throw another log on the fire. This is an example of a control loop. In the control loop, a variable (temperature) fell below the set point (your comfort level), and you took action to bring the process back into the desired condition by adding fuel to the fire. The control loop will now remain static until the temperature again rises above or falls below your comfort level.

Control loops in the process control industry work in the same way, requiring three tasks to occur:

- Measurement
- Comparison
- Adjustment

In the figure below, a level transmitter (LT) measures the level in the tank and transmits a signal associated with the level reading to a controller (LIC). The controller compares the reading to a predetermined value, in this case, the maximum tank level established by the plant operator, and finds that the values are equal. The controller then sends a signal to the device that can bring the tank level back to a lower level—a valve at the bottom of the tank. The valve opens to let some liquid out of the tank.

Many different instruments and devices may or may not be used in control loops (e.g., transmitters, sensors, controllers, valves, pumps), but the three tasks of measurement, comparison, and adjustment are always present.
Components of Control Loops and Equipments Monitored and Controlled in Process Control System

This section describes the instruments, technologies, and equipment used to develop and maintain process control loops. The previous section described the basic elements of control as measurement, comparison, and adjustment. In practice, there are instruments and strategies to accomplish each of these essential tasks. In some cases, a single process control instrument, such as a modern pressure transmitter, may perform more than one of the basic control functions. Other technologies have been developed so that communication can occur among the components that measure, compare, and adjust.

Primary Elements/Sensors

In all cases, some kind of instrument is measuring changes in the process and reporting a process variable measurement. Some of the greatest ingenuity in the process control field is apparent in sensing devices. Because sensing devices are the first element in the control loop to measure the process variable, they are also called primary elements. Examples of primary elements include:

- Pressure sensing diaphragms, strain gauges, capacitance cells
- Resistance temperature detectors (RTDs)
- Thermocouples
- Orifice plates
- Pitot tube
• Venturi tubes
• Magnetic flow tubes
• Coriolis flow tubes
• Radar emitters and receivers
• Ultrasonic emitters and receivers
• Annubar flow elements
• Vortex sheddar

Primary elements are devices that cause some change in their property with changes in process fluid conditions that can then be measured. For example, when a conductive fluid passes through the magnetic field in a magnetic flow tube, the fluid generates a voltage that is directly proportional to the velocity of the process fluid. The primary element (magnetic flow tube) outputs a voltage that can be measured and used to calculate the fluid’s flow rate. With an RTD, as the temperature of a process fluid surrounding the RTD rises or falls, the electrical resistance of the RTD increases or decreases a proportional amount. The resistance is measured, and from this measurement, temperature is determined.

**Transducers and Converters**

A *transducer* is a device that translates a mechanical signal into an electrical signal. For example, inside a capacitance pressure device, a transducer converts changes in pressure into a proportional change in capacitance.

A *converter* is a device that converts one type of signal into another type of signal. For example, a converter may convert current into voltage or an analog signal into a digital signal. In process control, a converter used to convert a 4–20 mA current signal into a 3–15 psig pneumatic signal (commonly used by valve actuators) is called a *current-to-pressure converter*.

**Transmitters**

A *transmitter* is a device that converts a reading from a sensor or transducer into a standard signal and transmits that signal to a monitor or controller. Transmitter types include:

• Pressure transmitters
• Flow transmitters
• Temperature transmitters
• Level transmitters
• Analytic (O [oxygen], CO [carbon monoxide], and pH) transmitters
Signals

There are three kinds of signals that exist for the process industry to transmit the process variable measurement from the instrument to a centralized control system.

1. Pneumatic signal
2. Analog signal
3. Digital signal

Pneumatic Signals

*Pneumatic signals* are signals produced by changing the air pressure in a signal pipe in proportion to the measured change in a process variable. The common industry standard pneumatic signal range is 3–15 psi. The 3 corresponds to the lower range value (LRV) and the 15 corresponds to the upper range value (URV). Pneumatic signalling is still common. However, since the advent of electronic instruments in the 1960s, the lower costs involved in running electrical signal wire through a plant as opposed to running pressurized air tubes has made pneumatic signal technology less attractive.

Analog Signals

The most common standard electrical signal is the 4–20 mA current signal. With this signal, a transmitter sends a small current through a set of wires. The current signal is a kind of gauge in which 4 mA represents the lowest possible measurement, or zero, and 20 mA represents the highest possible measurement. For example, imagine a process that must be maintained at 100 °C. An RTD temperature sensor and transmitter are installed in the process vessel, and the transmitter is set to produce a 4 mA signal when the process temperature is at 95 °C and a 20 mA signal when the process temperature is at 105 °C. The transmitter will transmit a 12 mA signal when the temperature is at the 100 °C set point. As the sensor’s resistance property changes in response to changes in temperature, the transmitter outputs a 4–20 mA signal that is proportionate to the temperature changes. This signal can be converted to a temperature reading or an input to a control device, such as a burner fuel valve. Other common standard electrical signals include the 1–5 V (volts) signal and the pulse output.

Digital Signals
Digital signals are the most recent addition to process control signal technology. Digital signals are discrete levels or values that are combined in specific ways to represent process variables and also carry other information, such as diagnostic information. The methodology used to combine the digital signals is referred to as protocol.

Manufacturers may use either an open or a proprietary digital protocol. Open protocols are those that anyone who is developing a control device can use. Proprietary protocols are owned by specific companies and may be used only with their permission.

**Indicators**

While most instruments are connected to a control system, operators sometimes need to check a measurement on the factory floor at the measurement point. An indicator makes this reading possible. An *indicator* is a human-readable device that displays information about the process. Indicators may be as simple as a pressure or temperature gauge or more complex, such as a digital read-out device. Some indicators simply display the measured variable, while others have control buttons that enable operators to change settings in the field.

**Recorder**

A *recorder* is a device that records the output of measurement devices. Many process manufacturers are required by law to provide process history to regulatory agencies, and manufacturers use recorders to help meet these regulatory requirements. In addition, manufacturers often use recorders to gather data for trend analyses. By recording the readings of critical measurement points and comparing those readings over time with the results of the process, the process can be improved.

Different recorders display the data they collect differently. Some recorders list a set of readings and the times the readings were taken; others create a chart or graph of the readings. Recorders that create charts or graphs are called *chart recorders*.

**Controllers**

A *controller* is a device that receives data from a measurement instrument, compares that data to a programmed set point, and, if necessary, signals a control element to take corrective action. *Local controllers* are usually one of the three types: pneumatic, electronic or programmable. Controllers also commonly reside in a digital control system.
Controllers may perform complex mathematical functions to compare a set of data to setpoint or they may perform simple addition or subtraction functions to make comparisons. Controllers always have an ability to receive input, to perform a mathematical function with the input, and to produce an output signal. Common examples of controllers include:

- **Programmable logic controllers** (PLCs)—PLCs are usually computers connected to a set of input/output (I/O) devices. The computers are programmed to respond to inputs by sending outputs to maintain all processes at set point.
- **Distributed control systems** (DCSs)—DCSs are controllers that, in addition to performing control functions, provide readings of the status of the process, maintain databases and advanced man-machine-interface.

All of the above mentioned components will be programmed and controlled with a measurement acquisition card. The next chapter will be showing how to implement a data acquisition system for a computer based process control system for oil mill.

The sensors, controllers, actuators and other components found on a process control will be simulated with an external simulator.